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(54) Title: METHOD AND APPARATUS FOR SUPPORTING AN INTER-SYSTEM SERVICE REQUEST FROM A DIGITAL TRAFFIC CHANNEL

(57) Abstract

A system and method for providing a requested service feature to a mobile station (16) in a cellular telecommunications system (10). A request (152) is received at a serving mobile switching center (18) to implement a service feature that is not currently being provided for the mobile station. It is determined that an inter-exchange hand-off request that includes a request for the service feature is necessary. The serving mobile switching center (18(1)) sends a hand-off request message (160) to a target mobile switching center (18(2)). This hand-off request includes data (161) that identifies the requested service. Responsive to the hand-off request message and the service request, the target mobile switching center determines if it is capable of supporting the requested service for the mobile station and sends a return message (166) to the serving mobile switching center indicating whether the target mobile switching center is capable of supporting the requested service feature. As an alternative, the serving exchange knows that the target exchange can support a specific service and, as part of a hand-off request message, requests a channel associated with the specific service.

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METHOD AND APPARATUS FOR SUPPORTING AN INTER-SYSTEM SERVICE REQUEST FROM A DIGITAL TRAFFIC CHANNEL

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates to a method and system for processing a request for a specific service feature and, in particular, for attempting an inter-system hand-off to access a switch and a channel capable of supporting the specific requested service feature.

Description of Related Art

In cellular telecommunications systems, each cell generally covers a particular geographic area. Communications with mobile stations located within that area are established through a base station associated with the cell. In many cases, however, there is an overlap in the coverage area for adjacent cells or for cells in co-located cellular networks (e.g., a digital network and an analog network serving similar service areas). Thus, at any given time, it is often possible for a particular mobile station to establish communications through a communication channel in any one of a plurality of different cells.

Which cell or base station is used can depend on one or more of a variety of factors. For example, the system might select a particular cell or base station based, in whole or in part, upon the received signal strength at the mobile station and/or the base stations for signals transmitted between the mobile station and base station. The availability of channels in a particular cell and the ability of the mobile station to operate in more than one mode (i.e., analog and digital) might be another factor. A dual-mode mobile phone, for instance, might initially request an analog channel, but if no analog channels are currently available, then a digital channel can be used. The desire to avoid interference between channels in different cells can be an additional factor that is used in selecting between base stations. In this respect, the same frequency is often used for channels in two different remotely located cells. Despite their remote locations, however, these channels can interfere with one another under certain circumstances. Therefore, it is often preferable to avoid using one of these

channels in order to help prevent any potential interference between the two channels, and this potential interference problem can also be considered in the channel allocation process.

Because of the ability of a mobile station to move around in a cellular telecommunications system, it is frequently necessary or desirable to execute a hand-off of the mobile station communication link between base stations served by one exchange (i.e., an intra-exchange hand-off), or from a base station associated with one exchange (the serving exchange) to another base station associated with a different exchange (the target exchange) (i.e., an inter-exchange hand-off). A hand-off can be initiated, for instance, in response to a determination that signals from the target exchange are stronger than the signals from the serving exchange. This type of hand-off is often necessary to maintain communications with a mobile station as the mobile station is transported from one cell to another. A hand-off can also be initiated to free up channel resources in a congested serving exchange by handing over the call connection to a channel in a less congested exchange with an overlapping service area. As another example, a hand-off might also be requested to reduce the possibility of interference with nearby cells operating on the same frequency.

Generally, inter-exchange hand-offs are more complex and require more processing resources than intra-exchange hand-offs because of the need to coordinate the hand-off between two separate exchanges. Reference is now made to FIGURES 1A-1B wherein there are shown message flow and network operation diagrams illustrating the execution of an inter-exchange hand-off of a mobile station 16(1) from a base station 14(1) served by a first mobile switching center 18(1) to a base station 14(2) served by a second mobile switching center 18(2). The mobile station 16(1), operating if capable in accordance with known mobile assisted hand-off (MAHO) principles, periodically makes downlink signal strength measurements 100 on the traffic channel (of the base station 14(1) served by the first mobile switching center 18(1)) that is currently being used. The mobile station 16(1) also periodically makes downlink signal strength measurements 102 on the control channels of network-identified base stations 14, including the base station 14(2) served by the second mobile switching center 18(2), which are associated with cells 12 that neighbor or overlap the cell 12 currently serving the mobile station 16(1). These signal strength

measurements are reported 104 to the currently serving base station 14(1). The base station 14(1) concurrently makes uplink signal strength measurements 106 on the traffic channel that is currently being used by the mobile station 16(1). These are the only measurements 106 made with respect to non-MAHO capable mobile stations 16.

The serving base station 14(1) processes the mobile station 16(1) reported 104 downlink signal strength measurements (100 and 102), if available, and the base station made uplink signal strength measurements (106) to determine first whether a hand-off is necessary (action 108) and second, if yes, to which base station or stations 14 (candidates) the hand-off could and/or should preferably occur (action 110). Alternatively, these actions 108 and 110 can be performed by the currently serving mobile switching center 18(1). It is now assumed that the base station 14(1) determines 108 from deteriorating measured uplink and/or downlink signal strengths that a hand-off is necessary. It is further assumed that an identification 110 is made of base station 14(2) as a candidate base station for hand-off. A request 112 for hand-off including information comprising an identification of the currently serving base station 14(1) or cell 12, the traffic channel being used for communication with mobile station 16(1) in the current base station 14(1), and the candidate base station 14(2) for hand-off, is then sent by the base station 14(1) to the serving mobile switching center 18(1). A hand-off if approved in this instance would comprise an inter-exchange hand-off because the candidate base station 14(2) is associated with a candidate mobile switching center 18(2) different from the serving mobile switching center 18(1) associated with the current base station 14(1). The foregoing description is only an example of the procedure used in making the determination to institute a hand-off. It will, of course, be understood that more than one candidate base station 14 might be identified by the process of action 110 for further hand-off consideration.

The currently serving mobile switching center 18(1) then sends a message 114 to the candidate mobile switching center 18(2) associated with the target base station 14(2) requesting verification of communications capability with the mobile station 16(1). It will be understood that multiple messages 114 can be sent if more than one candidate base station 14 has been identified for further hand-off consideration. The message 114, similar to the request 112 sent by the base station 14(1), includes information comprising an identification of the currently serving base station 14(1) or

cell and the traffic channel being used for communication with mobile station 16(1) in the currently serving base station 14(1). Responsive thereto, the candidate mobile switching center 18(2) sends a message 116 to the candidate base station 14(2) to make a verifying signal strength measurement (action 118) on the traffic channel being used by the currently serving mobile station 16(1). Again, it will be understood that multiple messages 116 can be sent by each candidate mobile switching center 18 if more than one candidate base station 14 associated with the candidate mobile switching center 18 has been identified for hand-off consideration.

The base station 14(2) then reports 120 the results of the verification signal strength measurement to the candidate mobile switching center 18(2). An evaluation of the verification signal strength measurement is then made (action 121) by the candidate mobile switching center 18(2) to confirm the location of the mobile station in view of expected signal strengths. After the evaluation, the candidate mobile switching center 18(2) forwards 122 the results of the verification measurement back to the serving mobile switching center 18(1). The results are then processed (action 124) by the serving mobile switching center 18(1) to determine whether a hand-off to the candidate base station 14(2) should be made. This processing 124 can involve a comparison between the results of the verification measurements for multiple base stations 14 associated with one or more mobile switching centers 18.

If the determination is affirmative with respect to the candidate base station 14(2), and if no other candidate base station 14 is identified as a better choice, the candidate base station 14(2) is selected as the preferred (or target) base station 14 (and the candidate mobile switching center 18(2) as the target mobile switching center 18). Following the selection of the target base station 14(2) and target mobile switching center 18(2), the serving mobile switching center 18(1) sends a message 126 to the target mobile switching center 18(2) requesting assignment (and reservation) of a traffic channel for hand-off to the target base station 14(2). In existing systems, however, there is no way to request an activation of a feature in connection with the request message 126. Instead, the request is merely for a channel that is of the same type as in the serving exchange.

A traffic channel is seized (action 128) by the target mobile switching center 18(2), and then both the target base station 14(2) and serving mobile switching center

18(1) are informed 130 of the assignment by the mobile switching center 18(2) of the traffic channel handled by the target base station 14(2). The serving mobile switching center 18(1) then sends a message 132 to the mobile station 16(1) via the currently serving base station 14(1) with a hand-off command directing the mobile station to switch to the assigned traffic channel handled by the target base station 14(2). The mobile station 16(1) then tunes to and accesses 134 the assigned traffic channel. When the base station 14(2) detects the mobile station access (action 136), the mobile switching centers 18(1) and 18(2) are informed 138, and the call is switched 140 to the mobile switching center 18(2) for further handling to complete the hand-off procedure.

Under the existing IS-41 and ANSI 41 specifications for digital cellular telecommunications, it is not possible to specify a particular service that is desired in connection with a hand-off request. This is because the channel resource at hand-off is selected by the target exchange in response to a request from the serving exchange based solely on a "ChannelData" parameter of the inter-system channel request message that does not permit an indication of a desired service. Under the IS-41 and ANSI 41 specifications, the inter-system channel request message comprises a "FacilitiesDirective" or "FacilitiesDirective2" message. Selection of a channel resource by the target exchange is based on a "ChannelData" parameter, such as the "TDMAChannelData," "CDMAChannelData," or "NAMPSChannelData" parameter of the "FacilitiesDirective" or "FacilitiesDirective2" message. Generally, the "ChannelData" parameters provide an identification of the channel that is currently serving the mobile station and do not provide any information relating to a desired service. Thus, the channel resource is selected by the target exchange to match the channel resource being provided in the serving exchange.

Although the "FacilitiesDirective" and "FacilitiesDirective2" messages also include a "CallMode" parameter, which can provide information about a desired service, the "CallMode" parameter currently is not used by the target exchange for allocating a particular channel resource (i.e., a channel that is capable of providing a requested service). As a result, when an inter-exchange hand-off is requested for a mobile station that is using a digital traffic channel in a CDMA, TDMA, or NAMPS system, which all use the IS-41 specification, the target exchange is not capable of processing a specific service request at inter-exchange hand-off. Thus, there is no

capability of ensuring that an inter-exchange hand-off is to an analog channel, if desired, or of ensuring that the new digital traffic channel is capable of handling a particular type of service.

There is a need, therefore, for a method and system for requesting a specified channel resource in connection with a hand-off attempt. A hand-off to obtain access to services that are not available in the current base station or serving exchange would be desirable, for example, where the serving exchange or base station has not yet been upgraded to handle a particular service, while an accessible exchange or base station in an adjacent or overlapping cell does have such capability. There is also a need for a method and system for requesting a known type of channel in a target exchange when, for example, the serving exchange knows that the target exchange is not capable of handling the current call mode. The types of services desired might include, in a case where a digital channel is currently being used, an analog channel or a channel with digital facsimile capabilities.

SUMMARY OF THE INVENTION

The present invention comprises a system and method for providing a service feature in a cellular telecommunications system. In response to the receipt of a request for activation of a selected service feature that is not currently being provided by a serving exchange, it is first determined that the serving exchange is not capable of providing the requested service or that a hand-off to another exchange is imminent. The serving exchange determines if there is a possibility that the mobile station could be served by a second exchange, where this determination is based, for example, on signal strength measurements provided by the mobile station. If such an exchange is identified, a hand-off request message that includes a service request is sent to the second exchange. This hand-off request message preferably comprises a hand-off request message in accordance with known inter-exchange protocols but modified to include an encoded indication of the service requested.

The second exchange receives the hand-off request message and retrieves the encoded service request to identify the requested service feature. The second exchange then determines if it is capable of supporting the requested service and if the second exchange includes an available channel that is both capable of supporting the

requested service and capable of communicating with the mobile station. If so, the second exchange allocates the selected channel for use by the mobile station. A return message is sent to the first exchange indicating that the requested service can be supported by the second exchange and identifying the allocated channel. After receiving this information, the serving exchange orders the mobile station, through a serving base station, to hand-off to the allocated channel of the target exchange so that the ongoing call can be continued and the requested service feature can be implemented.

In an alternative embodiment, when a hand-off of a mobile station is imminent and it is known that the target exchange does not support a service currently offered by the currently serving channel, the serving exchange attempts to identify an alternative service that is supported in the target exchange and that would therefore allow the ongoing communication to continue. This identification of an alternative service is accomplished either by examining data stored in the serving exchange or by querying the target exchange for a list of available services. Once an alternative service is selected, the serving exchange requests a hand-off to the target exchange and includes within the hand-off request a parameter requesting a channel that supports the selected alternative service. The target exchange examines the parameter and, as a result, allocates for the mobile station a channel capable of supporting the requested service.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention can be obtained by reference to the following Detailed Description when taken in conjunction with the accompanying Drawings wherein:

FIGURES 1A-1B are message flow and network operation diagrams illustrating the prior art execution of an inter-exchange hand-off of a mobile station 16 in response to an evaluation of signal strength measurements for uplink and/or downlink signals with the mobile station 16;

FIGURE 2 is a cell diagram illustrating an exemplary cell configuration for a cellular telephone network 10 in which an inter-exchange hand-off can be implemented in accordance with the present invention;

FIGURE 3 is a cell diagram illustrating two co-located cellular telephone networks 10 having different modes of operation in which an inter-exchange hand-off can be implemented in accordance with the present invention; and

FIGURES 4A-4B are message flow and network operation diagrams illustrating the operation of the networks 10 of FIGURES 2 and 3 in accordance with the present invention and in connection with the processing of an inter-system service request to initiate an inter-exchange hand-off of a mobile station 16.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

Referring now to FIGURE 2, there is shown a cell diagram illustrating an exemplary cell configuration for a cellular telephone network 10 in which an inter-exchange hand-off can be implemented in accordance with the present invention. The cellular telephone network 10 operates in accordance with one or more of a number of known air interface types including, for example, a code division multiple access (CDMA) protocol or a time division multiple access (TDMA) protocol, which provide for the use of at least one control channel and a plurality of traffic channels per cell 12. In the network 10, a base station 14 is provided for each of the cells 12. The base stations 14 engage in simultaneous communications with plural mobile stations 16 operating roughly within the area of the associated cell 12. The control channel assigned to each cell 12 is used to carry system control messages between the base station 14 and proximately located mobile stations 16, and also to assist in the network with mobile station cell re-selection. Such control messages include call originations, page signals, page response signals, location registration signals, traffic channel assignments, maintenance instructions, and cell selection or re-selection instructions. The traffic channels provided in each cell 12 are used to carry subscriber voice or data communications between the base station 14 and proximately located mobile stations 16.

The base stations 14 further communicate via signaling links and voice trunks 22 with a central control station, commonly referred to as a mobile switching center 18, which functions to control operation of the network 10. The mobile switching centers 18 are interconnected with each other and to the public switched telephone network (PSTN) 20 by the signaling links and voice trunks 22. The mobile switching

centers 18 operate to selectively connect subscriber voice and data communications to the mobile stations 16 through its base stations 14. Thus, the mobile switching centers 18 control system operation through and in response to the transmission of control messages over the control channels to set-up on the traffic channels calls that are either originated by or terminated at the mobile stations 16. The mobile switching centers 18 further control, through and in response to control and traffic channel transmissions, the hand-off of a subscriber communication from a traffic channel of one cell 12 to a traffic channel of another cell as the subscriber mobile station 16 roams throughout the cellular service area during an ongoing communication.

It is common within one overall cellular service area to have a plurality of system areas 32 (differentiated from each other by the fact that they have different system identifications (SIDs) and perhaps have different service providers). A boundary 34, passing between cells 12 along the border between two system areas 32, is shown in bold in FIGURE 2 to delimit the coverage area of each of the illustrated system areas, which, in this illustrated example, are served by different mobile switching centers 18. Alternatively, there can be a significant overlap between the coverage area of two adjacent system areas. Thus, in many cases it is possible for a mobile station to be in communication with any one of a plurality of base stations that are associated with different mobile switching centers 18. In this scenario, instances arise where it is desirable to initiate a hand-off 26 of a mobile station 16(1) from a first base station 14(1) in one system area 32 to a second base station 14(2) in another system area 32. Such a hand-off 26 might occur, for instance, when signals between the mobile station 16(1) and the second base station 14(2) become stronger than signals between the mobile station 16(1) and the first base station 14(1). Thus, the mobile station 16(1), in conjunction with base station 14 information and orders exchanged with and between the mobile switching centers 18, has an opportunity through hand-off to change the base station through which cellular radio communications are being effectuated.

In addition to the above-described configuration, it is also common to have two co-located (overlapping) cellular telephone networks 10 that have different modes of operation, as illustrated in FIGURE 3. A first network 10(1), for instance, might serve a particular geographical area according to a digital mode of operation, while a second

network 10(2), having at least a portion of its coverage area in common with the first network 10(1), might use an analog mode of operation. Although each of the cells 12 for the two networks 10 are depicted in FIGURE 3 as having an identical physical extent for convenience of illustration, the service areas of the cells 12 for the two networks are generally unrelated to one another. Instances can arise in this situation where it is desirable to initiate a hand-off 28 of a mobile station 16(1) from a base station 14(1) associated with the first network 10(1) to a base station 14(2) associated with the second network 10(2). A dual-mode mobile station, for example, might have a preferred mode of operation that compels hand-off to the second network.

Reference is now made to both FIGURES 2 and 3. Inter-exchange hand-offs are generally known in the art. In accordance with the present invention, however, there is provided a method and system for executing an inter-system hand-off from a digital first exchange to a second exchange in order to support an initiation of a particular service feature. In response to a request for a particular service for use by or in connection with a mobile station 16(1), the serving mobile switching center 18(1), which is determined to be incapable of providing the requested service, sends a channel resource request message to a target mobile switching center 18(2) via a signaling link 22, requesting a channel that is capable of providing the requested service.

The target exchange 18(2) examines the channel resource request message to determine what type of channel resource is needed. If a channel of the requested type is not available in the target exchange 18(2), a return request message is sent to the serving exchange 18(1) denying the request. On the other hand, if a channel of the requested type is available in the target mobile switching center 18(2) and assuming that the base station 14 handling the channel is close enough to the mobile station 16(1) to support acceptable communications, that channel is allocated for use by the mobile station 16(1) and a return message granting the channel resource request is sent to the first mobile switching center 18(1). The first mobile switching center 18(1) then orders the mobile station 16(1), through the base station 14(1), to hand-off to a base station 14(2) associated with the target mobile switching center 18(2) wherein the service feature requested in, but not provided in the initial serving exchange 18(1) is implemented. It will be understood that this process can involve either a hand-off 26

from a serving base station 14(1) in a first system area 32 to a target base station 14(2) in an adjacent system area 32 (as shown in FIGURE 2) or a hand-off 28 from a serving base station 14(1) in a first network 10(1) to a target base station 14(2) in a co-located second network 10(2) (as shown in FIGURE 3).

Reference is now made in combination to FIGURES 2, 3 and 4A-4B wherein FIGURES 4A-4B are message flow and network operation diagrams illustrating the operation of the networks 10, 10(1), and 10(2) of FIGURES 2 and 3 in accordance with the present invention and in connection with the processing of an inter-system service request to initiate an inter-exchange hand-off of a mobile station 16(1) from a base station 14(1) served by a first mobile switching center 18(1) to a base station 14(2) served by a second mobile switching center 18(2).

As discussed with reference to FIGURES 1A-1B, the mobile station 16(1), operating if capable in accordance with known mobile assisted hand-off (MAHO) principles, periodically makes downlink signal strength measurements 100 on the current traffic channel of the currently serving base station 14(1), and also periodically makes downlink signal strength measurements 102 on the control channels of base stations 14 that are associated with cells 12 that neighbor or overlap the cell 12 that is currently serving the mobile station 16(1). These signal strength measurements are reported 104 to the currently serving base station 14(1) and can be processed therein or, as indicated at 105, can be further passed on to the serving mobile switching center 18(1) for processing. The base station 14(1) concurrently makes uplink signal strength measurements 106 on the traffic channel that is currently being used by the mobile station 16(1). These measurements can also be processed in the base station 14(1) or, as indicated at 107, can be passed on to the serving mobile switching center 18(1) for processing.

It is assumed that, at some point during these periodic measurements, a service feature code requesting a particular service feature is received (as generally indicated at 150), wherein the service feature is not currently being provided by the serving mobile switching center 18(1). As a result, a service request 152 is transmitted from a mobile station 16(1) to a first mobile switching center 18(1), via a base station 14(1) associated with the current serving exchange 18(1). The service request 152 can be the result of an explicit request 150 by a mobile user (i.e., by keying in and sending

a service code) or can be generated as a result of an action by the mobile user (i.e., an attempted fax transmission) that implicates certain service requirements (i.e., a channel capable of supporting fax transmissions).

As an alternative, a similar service request 152' can also be internally generated in the serving exchange 18(1) in response to a determination (as indicated at 150') that a particular service is needed. For example, such a determination 150' might be in response to an indication received from a home location register (HLR) 19 associated with the mobile station 16(1) that a certain service should be activated in accordance with user preferences stored in the home location register 19. The service request 152' might also be generated by the mobile switching center 18 to request a service necessary for an incoming call or to attempt to provide a more efficient allocation of channel resources. In this case, the service request 152' is typically generated only if it is known that the mobile station 16(1) is capable of using that service. Generally, the service request 152 or 152' is only sent to another mobile switching center 18 if the requested service is not available in the serving cell 12 or if a hand-off attempt to the target exchange 18(2) is imminent. With respect to the latter, for example, the service request 152 or 152' is sent if it is determined (at step 108) that a hand-off to the target exchange 18(2) is appropriate at approximately the same time that a request for the activation of a particular service feature 150 or 150'. The hand-off determination can be based, for instance, on an evaluation uplink and/or downlink signal strength measurements and can be made either in the mobile switching center 18(1), in accordance with signal strength measurements received by the mobile switching center 18(1) in steps 105 and 107, or in the base station 14(1), in accordance with signal strength measurements received by the base station 14(1) in steps 104 and 106.

After receiving the service request 152 or 152', the first mobile switching center 18(1) determines if the requested service is available in the serving exchange 18(1), as indicated at step 154. Assuming that the service is not available, the serving mobile switching center 18(1) attempts to identify, at step 158, one or more candidate base stations 14 in at least one different exchange 18 that might be capable of serving the mobile station 16(1) and, hopefully, of providing the requested service. The identification of the candidate base stations 14 can be based on information stored in the serving exchange 18(1) or on the periodic signal strength measurements taken by

the mobile station 16(1) and/or serving base station 14(1). In addition, although the processing of service requests is shown and described as being carried out in a mobile switching center 18, it will be appreciated by those skilled in the art that the various functionalities can be implemented in more than one location or device and that the specific mechanism for carrying out the functionalities does not necessarily have to involve a mobile switching center 18. For example, some or all of the processing can be implemented in a base station controller (not shown).

After identifying the potential hand-off candidate or candidates, the verification process is initiated. The currently serving mobile switching center 18(1) sends a message 114 to the mobile switching center 18(2) associated with the candidate base station 14(2) requesting verification of communications capability with the mobile station 16(1). Again, multiple messages 114 can be sent if more than one candidate base station 14 has been identified at step 158 for further hand-off consideration. Responsive to the verification request message 114, each candidate mobile switching center 18(2) sends a message 116 to each candidate base station 14(2) to make a verifying signal strength measurement (action 118) on the traffic channel being used by the mobile station 16(1).

The candidate base station 14(2) then reports 120 the results of the verification signal strength measurement to the candidate mobile switching center 18(2). An evaluation of the verification signal strength measurement is then made (action 121) by the candidate mobile switching center 18(2), and the candidate mobile switching center 18(2) forwards 122 the results of the verification measurement back to the serving mobile switching center 18(1). The results are then processed (action 124) by the serving mobile switching center 18(1) to determine whether a hand-off to the candidate base station 14(2) can be made and, if necessary, which of multiple candidate base stations 14 is preferred.

If the response to the verification request is favorable (i.e., hand-off to the candidate exchange 18(2) is possible and no better candidate base stations 14(2) are identified), the candidate base station 14(2) is selected as the target base station 14(2). The serving mobile switching center 18(1) then sends an inter-system channel request message 160 (e.g., a "FacilitiesDirective" or "FacilitiesDirective2" message, in accordance with the IS-41 and ANSI 41 specification) to the target mobile switching

center 18(2) (MSC) requesting an allocation of a specific channel resource. Alternatively, the inter-system channel request message 160 is only sent if it is known that the target exchange 18(2) is capable of providing the service.

Unlike the assignment request message 126 illustrated in FIGURES 1A-1B, an existing or a new parameter 161 of an inter-system signaling protocol is used to encode the initial service request 152 within the inter-system channel request message 160 and to indicate the type of resource needed by the mobile station 16. Under the IS-41 or ANSI 41, for example, an indication of the type of channel resource needed can be transmitted in a "CallMode" parameter, such as the "TDMACallMode," "CDMACallMode," or "NAMPSCallMode" parameter (or by a "ServiceCode" parameter, such as currently exists in TDMA specifications), by specifying that a service is requested via a particular type of channel by using some of the spare bits currently available in the parameter. As a result, when the relevant bits are "turned on," the parameter is being used to indicate the type of channel resource that is being requested. In the alternative, a new parameter based on the existing "TDMACallMode," "CDMACallMode," or "NAMPSCallMode" parameters and entitled "RequestedChannelResource" can be introduced.

Upon receipt of the inter-system channel request message 160, again unlike the prior art method discussed in connection with FIGURES 1A-1B, the second mobile switching center 18(2) extracts the encoded service request 161 from the inter-system channel request message 160 (i.e., if such a message is present or if selected bits indicate that a particular service request is present) and determines if the service is supported by a switch associated with the target exchange 18(2) at step 162. If so, the second mobile switching center 18(2) further determines at step 164 if an idle channel capable of providing the requested service is available. In some cases, this determination 164 merely requires any idle channel in the target base station, such as where the requested service is an analog channel and all of the channels in the target exchange 18(2) support analog communications. In other cases, however, the determination 164 if there is an idle channel capable of supporting the requested service might require the identification of a particular type of idle channel, such as where the requested service is an analog channel and only some of the channels in the target base station 14(2) support analog communications.

If the target exchange 18(2) does not support the requested service or if no channels capable of supporting the requested service are available, then the target mobile switching center 18(2) returns an error or fail indication in a return result message 166. In response, the first mobile switching center 18(1) can attempt to locate an appropriate channel in another exchange 18 at step 167 by returning to step 158 to try to identify an alternate exchange 18 (as indicated at 168) or by returning to step 160 (as indicated at 169) to send an inter-system channel request message 160 to a third mobile switching center 18(3) (see FIGURE 3), if the previous verification procedure identified a base station 14(3) (i.e., a second-best target base station 14) in a third exchange 18 that is capable of communicating with the mobile station 16(1). If an alternate exchange 18 cannot be located or if all attempts to hand-off to such exchanges 18 fail, the mobile station 16(1) is notified by a fail message 170 that the service requested by the user through the initial service code has been denied.

If, on the other hand, a channel capable of supporting the requested service is available, the target mobile switching center 18(2) seizes the channel (action 172) and allocates the channel for use by the mobile station 16(1). The target base station 14(2) is informed 130 of the assignment by the mobile switching center 18(2), and a return result message 174 is sent to the currently serving mobile switching center 18(1) granting the service request and including information about the granted channel resource. Under the IS-41 or ANSI 41 specification, in the case of either a denial or a grant of the service request, the return result message 166 or 174 is a "FacilitiesDirective Return Result" or "FacilitiesDirective2 Return Result" message.

The serving mobile switching center 18(1) then sends a message 132 through the currently serving base station 14(1) and to the mobile station 16(1) via a Dedicated Digital Traffic Channel Hand-off Message. This message contains a hand-off command directing the mobile station to switch to the assigned channel handled by the target base station 14(2). The mobile station 16(1) then tunes to and accesses 134 the assigned channel. When the base station 14(2) detects the mobile station access (action 136), the mobile switching centers 18(1) and 18(2) are informed 138, and the call is switched 140 to the mobile switching center 18(2) for further handling to complete the hand-off procedure.

In an alternative embodiment, when it is known that the current type of channel resource is not supported in the target exchange, the inter-system channel request message can be used to specify a channel type that is supported in the target exchange. This is desirable, for instance, when the serving exchange has been upgraded to support new services, while the target exchange has not. If an ongoing call in the serving exchange is using a channel supporting a particular new service, it would normally not be possible to hand the call over to the target exchange because it does not include channels that support the new service. In addition, in existing systems, the target exchange cannot process a request for a different type of channel resource. Instead, it can only select a channel resource based upon the identity of the existing channel resource in the currently serving exchange (as indicated in the inter-system channel request message). Since a channel corresponding to the existing channel does not exist in the target exchange, the hand-off is typically refused. In accordance with the present invention, however, a hand-off to a different type of channel resource that is known to be available in the target exchange is possible.

According to this embodiment, it is determined that a hand-off is necessary as in the prior embodiment (i.e., in accordance with steps 100 - 108, as discussed above). Based on this determination (at step 108), the serving exchange 18(1) identifies, at step 158, one or more candidate base stations 14, and the verification process (steps 114 - 124) is initiated. Upon completion of the verification process, in which a preferred candidate base station 14(2) is identified at step 124, the serving exchange 18(1) determines at step 125 which services or modes of operation the target base station 14(2) is capable of supporting. This determination 125 can be performed, for instance, by examining information about the target exchange 18(2) stored in the serving exchange 18(1) or by querying the target exchange 18(2). If the target exchange 18(2) does not include channels that support a service or mode of operation used by the currently serving channel, the serving exchange 18(1) selects a type of channel that is available in the target exchange 18(2) and sends an inter-system channel request message 160 that includes a parameter 161 requesting a channel of the selected type. Further processing of the call and the hand-off generally occur in accordance with steps 162-174 and steps 130-140.

A more complete understanding of the invention can be obtained by further reference to the following examples of possible scenarios in which the invention can be used to provide improved system operations:

(1) In the first example, a dual-mode mobile phone is operating in a digital cellular telecommunications exchange. The exchange does not have analog capabilities because, for example, the exchange does not include any analog transceivers or the exchange does not include software necessary for supporting analog cellular communications. There is a dual-mode cellular telecommunications exchange, however, that serves an overlapping area, which includes the current location of the mobile phone. It is assumed that the mobile phone is capable of using and is permitted to use either of the exchanges.

Under existing systems, if the mobile phone transmits a service request code to the serving base station requesting that it be switched only to an analog mode of operation, the request will not be granted. This is because, first, the digital exchange cannot support analog communication. In addition, although the mobile phone could conduct analog communications in the dual-mode network, there is no procedure for switching to an analog channel in the dual-mode exchange while maintaining the ongoing call because the digital cellular protocol does not permit the dual-mode exchange (i.e., target exchange) to process a specific request from a serving exchange for an analog channel only. Rather, the request, whether requesting a digital, analog, or dual-mode exchange, is accepted but is processed by the target exchange based solely on the serving channel characteristics: in other words, the specific request is essentially ignored and the only type of channel that can be obtained by the inter-exchange hand-off request is a digital channel having the same capabilities as the channel provided by the currently serving base station.

In accordance with the present invention, however, the inter-exchange hand-off request can include a "RequestedChannelResource" parameter indicating whether a service is needed. In the present example, the hand-off request, including the "RequestedChannelResource" parameter, is sent from the digital exchange to the overlapping dual-mode exchange. The dual-mode exchange receives the request and examines the "RequestedChannelResource" parameter to determine if a particular service is required. Based on this examination, the dual-mode exchange determines

that an analog channel is required and allocates an analog channel for use by the mobile phone. Thus, in contrast to existing systems, the mobile phone is able to obtain a service feature (i.e., an analog channel) in the dual-mode exchange that is not initially being provided by the digital exchange.

(2) In the second example, a dual-mode mobile phone is operating in a first dual-mode cellular telecommunications exchange that serves a particular geographical area. A second dual-mode cellular telecommunications exchange serves an adjacent geographical area. Again, it is assumed that the mobile phone is capable of using and is permitted to use either of the exchanges.

As the mobile phone moves from the area of the first exchange toward the area of the second exchange, it is eventually determined that a hand-off of the mobile phone is necessary. In accordance with typical hand-off procedures, the first exchange identifies several candidate base stations and transmits verification request messages to each exchange that includes a candidate base station. A verification report message for each candidate base station is thereafter returned to the first exchange. Based on an evaluation of the various verification reports, a target base station is selected. Here, it is assumed that a base station associated with the second exchange is selected as the target base station.

Prior to completing hand-off, the mobile phone transmits a service request code to the serving base station in the first exchange requesting that it be switched to an analog mode of operation. It is assumed, however, that the request cannot be granted prior to sending the channel request message because, for instance, no analog channels are currently available in the serving exchange or because there is not enough time to process the request before sending the channel request message.

In existing systems, the imminent hand-off would occur without regard to the received service request. As a result, the request might be lost during the hand-off procedure. Alternatively, even if the request is not lost, the request must be separately processed in the second exchange after completion of the hand-off, thereby causing additional processing resources to be expended and delaying the initiation of the requested service.

In accordance with the present invention, on the other hand, the request is incorporated into the channel request message, which is sent following the selection

of the target base station. Thus, the channel request message includes a parameter identifying the need for an analog channel. Upon receipt of the channel request message, the second exchange examines this parameter and determines that an analog channel is required. An analog channel of the target base station is allocated for the mobile station, and the second exchange sends a return request message that includes information about the allocated channel. The first exchange directs the mobile station, via the serving base station, to hand-off to the allocated channel of the target base station. Therefore, in contrast to existing systems, the mobile phone is able to obtain a service feature (i.e., an analog channel) in the second dual-mode exchange that is not initially being provided by the first dual-mode exchange.

(3) In the third example, a digital mobile phone is operating in a first digital cellular telecommunications exchange that serves a first geographical area. A second digital cellular telecommunications exchange serves a second geographical area, and a third digital telecommunications exchange serves a third geographical area. It is assumed that the mobile phone is capable of using and is permitted to use any of the three exchanges. It is further assumed that the mobile station is in a location where there is some overlap between the three geographical areas (i.e., the mobile phone can conduct communications using a base station in any one of the three exchanges).

The mobile phone attempts to initiate a facsimile transmission that requires a channel capable of handling digital fax services. The serving (first) exchange, however, cannot currently support digital fax services. In existing systems, the attempted transmission would fail. In accordance with the present invention, however, the first exchange, upon determining that it cannot support the requested service, attempts to identify potential hand-off candidates in an effort to find an exchange that can support the service. Using known mobile assisted hand-off procedures, two candidate base stations are identified--one in the second exchange and another in the third exchange. Based upon the verification process, the base station in the second exchange is determined to have a slightly stronger signal strength with respect to the mobile phone and is selected as the target base station.

Next, the first exchange sends a channel request message to the second exchange, wherein the channel request message identifies the target base station and includes a parameter indicating that a channel capable of providing digital fax services

is required. Upon receiving the channel request message, the second exchange determines that the target base station cannot provide digital fax services and sends a return request message to the first exchange denying the request. As a result, the previously identified candidate base station in the third exchange becomes the new target base station and another channel request message, similar to the first, is sent to the third exchange. The third exchange examines the included service code parameter and determines that a channel capable of supporting digital fax services is required. Such a channel is allocated by the third exchange and a return request message is sent to the first exchange providing information about the allocated channel. The first exchange sends a command to the mobile station, via the currently serving base station, directing the mobile station to hand-off to the allocated channel in the third exchange. In accordance with the invention, therefore, the mobile phone is able to obtain a service feature (i.e., a channel with digital fax capabilities) in the third exchange that is not initially being provided by the first exchange.

(4) In the fourth example, a dual-mode mobile phone is operating in a digital mode in a first, dual-mode cellular telecommunications exchange that serves a particular geographical area. A second, analog-only cellular telecommunications exchange serves an adjacent geographical area. Again, it is assumed that the mobile phone is capable of using and is permitted to use either of the exchanges.

As the mobile phone moves from the area of the first exchange toward the area of the second exchange, it is eventually determined that a hand-off of the mobile phone is necessary. In accordance with typical hand-off procedures, the first exchange identifies several candidate base stations and transmits verification request messages to each exchange that includes a candidate base station. A verification report message for each candidate base station is thereafter returned to the first exchange. Based on an evaluation of the various verification reports, a target base station is selected. Here, it is assumed that a base station associated with the second exchange is selected as the target base station. Based on information about the second exchange stored in the first exchange, it is known that the second exchange does not support digital-mode communications. Thus, the current digital communication of the mobile phone cannot be continued if hand-off occurs.

In existing systems, the hand-off would not be possible unless the mobile phone is first switched from a digital channel to an analog channel in the first exchange before a hand-off is attempted. This is because the second exchange, in responding to a hand-off request, looks only at the current channel type in selecting the type of channel that it provides. Because it does not have any digital channels, the hand-off would normally be rejected.

In accordance with the present invention, however, the first exchange recognizes that the second exchange is only capable of analog operation. The inter-exchange hand-off request therefore includes a "RequestedChannelResource" parameter, or some other parameter indicating that an analog channel is needed (i.e., instead of allowing the second exchange to infer that a digital channel only is needed based on the "ChannelData" parameter). The analog exchange receives the request and examines the "RequestedChannelResource" parameter to determine what type of channel is required. Based on this examination, the second exchange determines that an analog channel is required and allocates an analog channel for use by the mobile phone. The second exchange sends a return request message that includes information about the allocated channel, and the first exchange directs the mobile station, via the serving base station, to hand-off to the allocated channel of the target base station. Thus, in contrast to existing systems, the mobile phone is able to hand-off to an analog channel in the analog exchange even though the mobile phone is operating under a digital mode in the dual-mode exchange.

Although various embodiments of the method and apparatus of the present invention have been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it is understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications, and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

WHAT IS CLAIMED IS:

1. A method for providing a service feature in a mobile telecommunications system, comprising the steps of:

receiving a request in a serving exchange with respect to a mobile station for access to a certain service, wherein said certain service is not currently being provided with respect to the mobile station;

identifying a need to perform an inter-exchange hand-off of communications with the mobile station;

sending an inter-exchange hand-off request from said serving exchange to a target exchange, wherein said inter-exchange hand-off request includes data identifying the requested certain service;

determining if the target exchange is capable of supporting the requested certain service by examining the data identifying the requested certain service; and

sending a return message from the target exchange to the serving exchange indicating whether the target exchange is capable of supporting the requested certain service.

2. The method of claim 2 wherein the determination if the target exchange is capable of supporting the requested certain service is performed regardless of a channel type currently being used in the serving exchange.

3. The method of claim 1 wherein said serving exchange comprises a digital cellular telecommunications system.

4. The method of claim 3 wherein the request for access to the certain service comprises a request for access to an analog traffic channel.

5. The method of claim 3 wherein the request for access to the certain service comprises a request for access to a digital facsimile service.

6. The method of claim 1 wherein the step of identifying a need to perform an inter-exchange hand-off includes the step of determining that the serving exchange cannot support the requested service.

7. The method of claim 1 wherein the step of identifying a need to perform an inter-exchange hand-off includes the step of determining that an inter-exchange hand-off is imminent.

8. The method of claim 7 wherein the inter-exchange hand-off is in response to an evaluation of a signal strength of at least one signal transmitted between the mobile station and the target exchange.

9. The method of claim 1 further comprising the step of determining that said serving exchange cannot support the requested service, and wherein the return message includes an error message.

10. The method of claim 1 further comprising the step of determining that the target exchange is capable of supporting the requested certain service.

11. The method of claim 10 further comprising the step of allocating for said mobile station a channel of said target exchange, wherein said channel is capable of supporting the requested certain service.

12. The method of claim 11 wherein the return message from the target exchange to the serving exchange identifies the allocated channel of the target exchange.

13. The method of claim 12 further comprising the step of ordering the mobile station to hand-off to the allocated channel of the target exchange.

14. The method of claim 1 wherein the step of determining if the target exchange is capable of supporting the requested certain service includes the step of

determining if a switch associated with the target exchange supports the requested certain service.

15. The method of claim 1 wherein the step of determining if the target exchange is capable of supporting the requested certain service includes the step of determining the availability of a channel accessible by the mobile station and capable of supporting the requested certain service.

16. A cellular telecommunications system, comprising:

a first exchange through which a mobile station cellular communication is initially handled, and from which an inter-exchange hand-off request is issued, wherein said inter-exchange hand-off request includes a service request parameter indicating that a channel supporting a selected service feature is needed, said selected service feature not currently being provided by the first exchange; and

a second exchange receiving said inter-exchange hand-off request, said second exchange operating to examine the service request parameter to determine if the selected service feature is capable of being supported by the second exchange and to respond to the inter-exchange hand-off request by allocating for the mobile station a channel supporting the selected service feature.

17. The system of claim 16 further comprising:

a first plurality of base stations connected to said first exchange, at least one of said first plurality of base stations initially handling the mobile station cellular communication; and

a second plurality of base stations connected to said second exchange, at least one of said second plurality of base stations handling cellular communications over the allocated channel.

18. The system of claim 17 wherein the first exchange comprises a first mobile switching center for controlling the operation of the first plurality of base stations and the second exchange comprises a second mobile switching center for controlling the operation of the second plurality of base stations.

19. The system of claim 17 wherein the second exchange further operates to send a return message to the first exchange identifying the allocated channel.

20. The system of claim 19 wherein the first exchange further operates to order the mobile station to hand-off to said base station handling cellular communications over the allocated channel.

21. The system of claim 16 wherein said first exchange comprises a digital cellular telephone exchange.

22. The system of claim 16 wherein at least a portion of a service area of the first exchange overlaps a service area of the second exchange.

23. The system of claim 16 wherein the first exchange further operates to receive a request for a selected service feature from said mobile station.

24. The system of claim 23 wherein the first exchange operates to send the inter-exchange hand-off request in response to a determination that the selected service feature is not available in the first exchange.

25. The system of claim 24 wherein the second exchange operates to determine that the selected service feature is available in the second exchange.

26. The system of claim 16 wherein the first exchange operates to send the inter-exchange hand-off request in response to an evaluation of a signal strength of at least one signal transmitted between the mobile station and the target exchange.

27. The system of claim 16 wherein the first exchange operates to send the inter-exchange hand-off request in response to an indication of a preferred mode of operation for the mobile station.

28. A method for providing a service feature to a mobile station in a cellular telecommunications system, comprising the steps of:

receiving in a first exchange a request for access to an analog channel, said first exchange currently serving said mobile station according to a digital telecommunications protocol;

sending an inter-exchange hand-off request from said first exchange to a second exchange supporting analog services, wherein said inter-exchange hand-off request includes a parameter identifying the request for access to an analog channel;

examining said parameter, in the second exchange, to determine that the inter-exchange hand-off request includes a request for access to an analog channel;

determining in response to said examination that the second exchange is capable of providing access to an analog channel;

allocating for said mobile station an analog channel in the second exchange in response to the inter-exchange hand-off request; and

sending a return message from the second exchange to the first exchange containing data identifying the allocated analog channel.

29. The method of claim 28 wherein said parameter identifying the requested service comprises a "CallMode" parameter.

30. The method of claim 28 wherein said parameter identifying the requested service comprises a parameter dedicated to identify the requested channel resource.

31. The method of claim 28 wherein said parameter identifying the requested service comprises a "ServiceCode" parameter.

32. A method for performing an inter-exchange hand-off in a mobile telecommunications system, comprising the steps of:

identifying a need to perform an inter-exchange hand-off of communications involving a mobile station;

determining that a target exchange cannot support a certain service, wherein the mobile station is operating in a serving exchange according to the certain service;

identifying an alternate service for use in the target exchange to maintain said communications involving the mobile station;

sending an inter-exchange hand-off request from the serving exchange to the target exchange, wherein the inter-exchange hand-off request includes data identifying the alternate service;

examining, in the target exchange, the data identifying the alternate service; and

allocating for the mobile station a channel in the target exchange that is capable of supporting the alternate service.

33. The method of claim 32 wherein the alternate service comprises an analog telecommunications channel.

34. The method of claim 33 wherein the certain service comprises a digital telecommunications channel.

35. The method of claim 32 further comprising the step of determining if the target exchange is capable of supporting the alternate service.

36. The method of claim 32 further comprising the step of sending a return message from the target exchange to the serving exchange identifying the allocated channel.

37. The method of claim 32 wherein the step of identifying the need to perform the inter-exchange hand-off includes evaluating a signal strength of at least one signal transmitted between the mobile station and the target exchange.

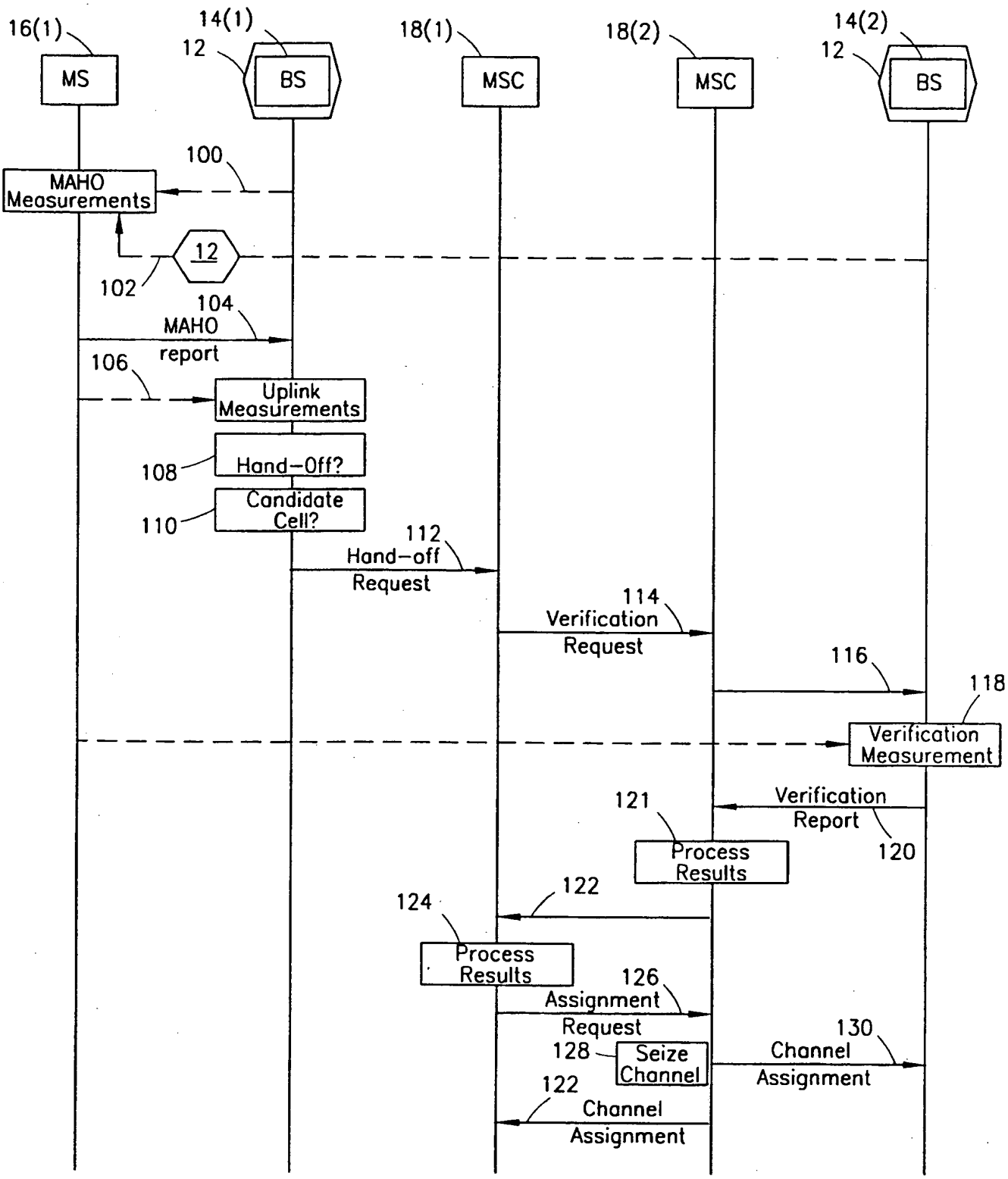


FIG. 1A
(PRIOR ART)

38. The method of claim 32 wherein the step of determining that the target exchange cannot support the certain service comprises examining information stored in the serving exchange.

39. The method of claim 32 wherein the step of determining that the target exchange cannot support the certain service comprises the steps of:

querying the target exchange; and

receiving an indication that the target exchange cannot support the certain service.

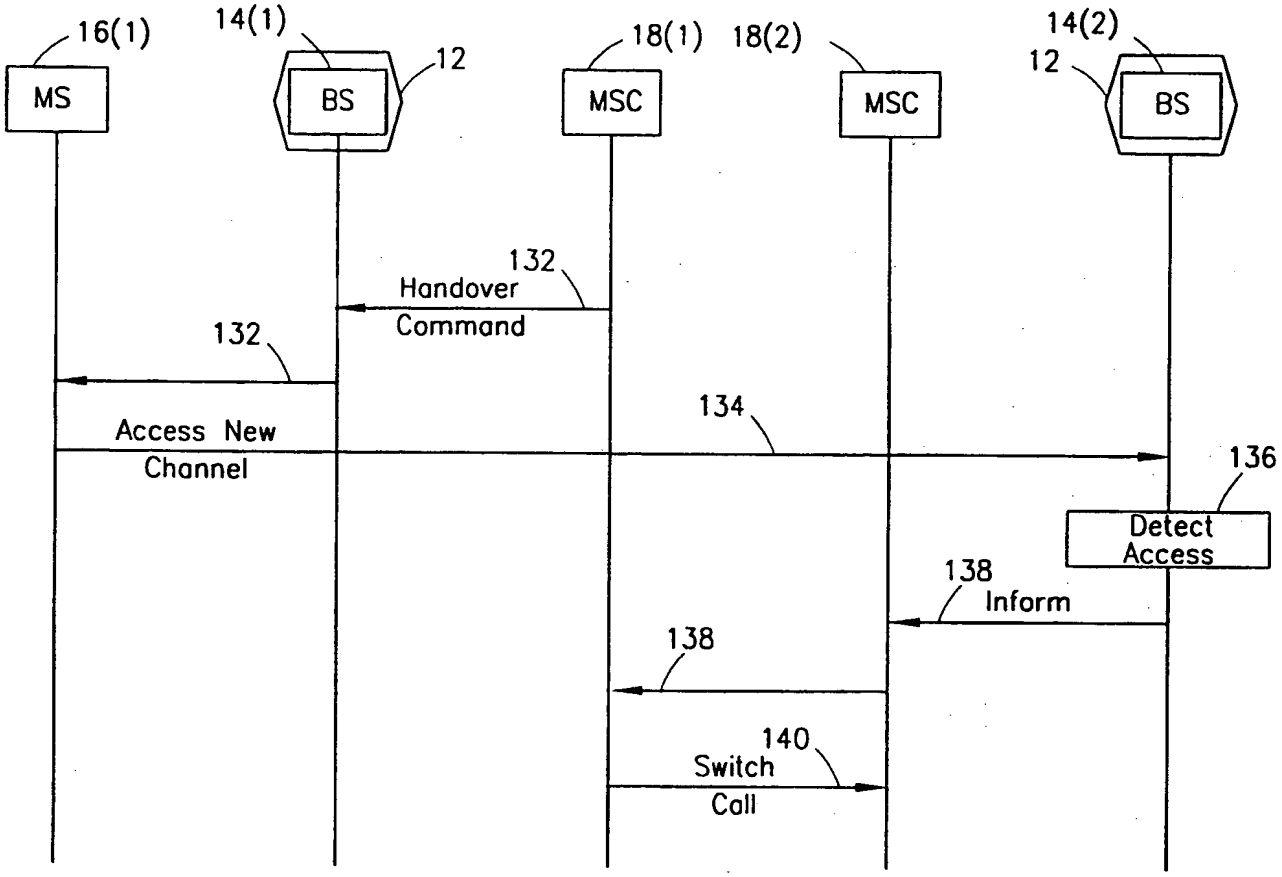
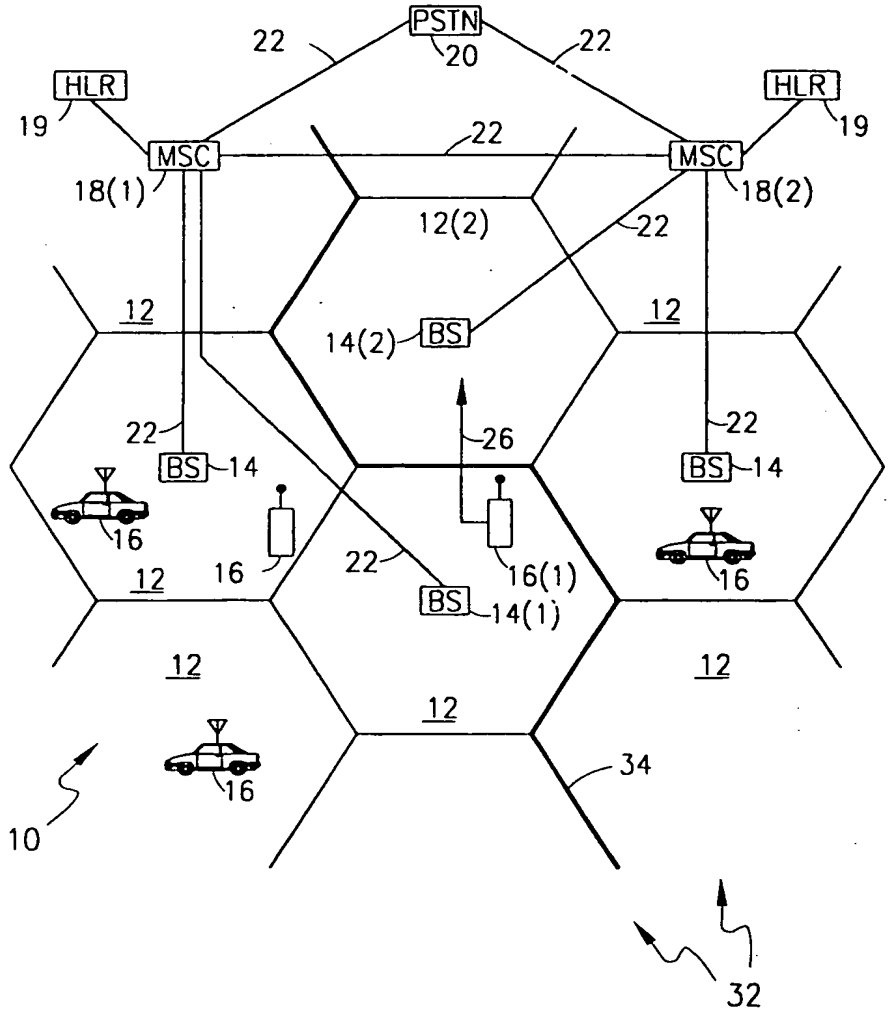


FIG. 1B
(PRIOR ART)


PSTN
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HLR
19
HLR
19
MSC
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MSC
18(2)
22
12(2)
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14(2)
BS
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BS
14
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10
32

FIG. 2

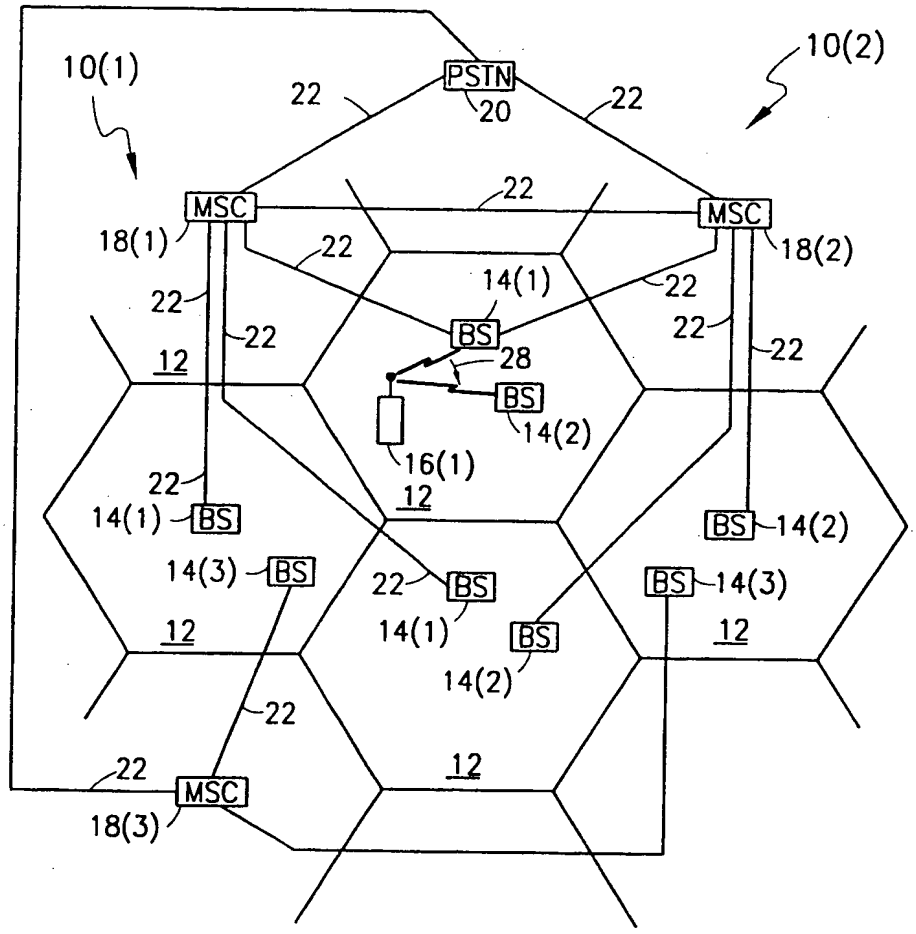

FIG. 3

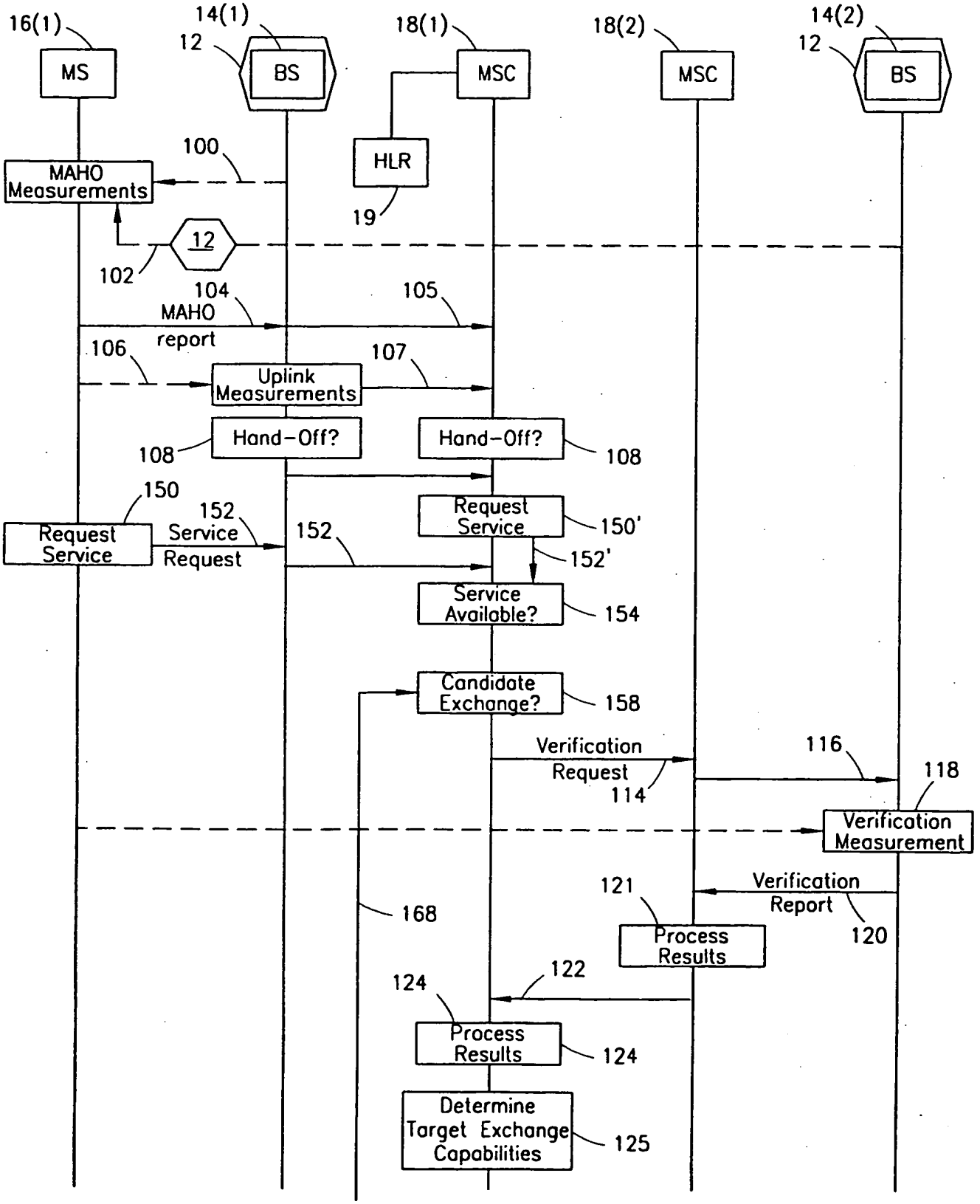

FIG. 4A

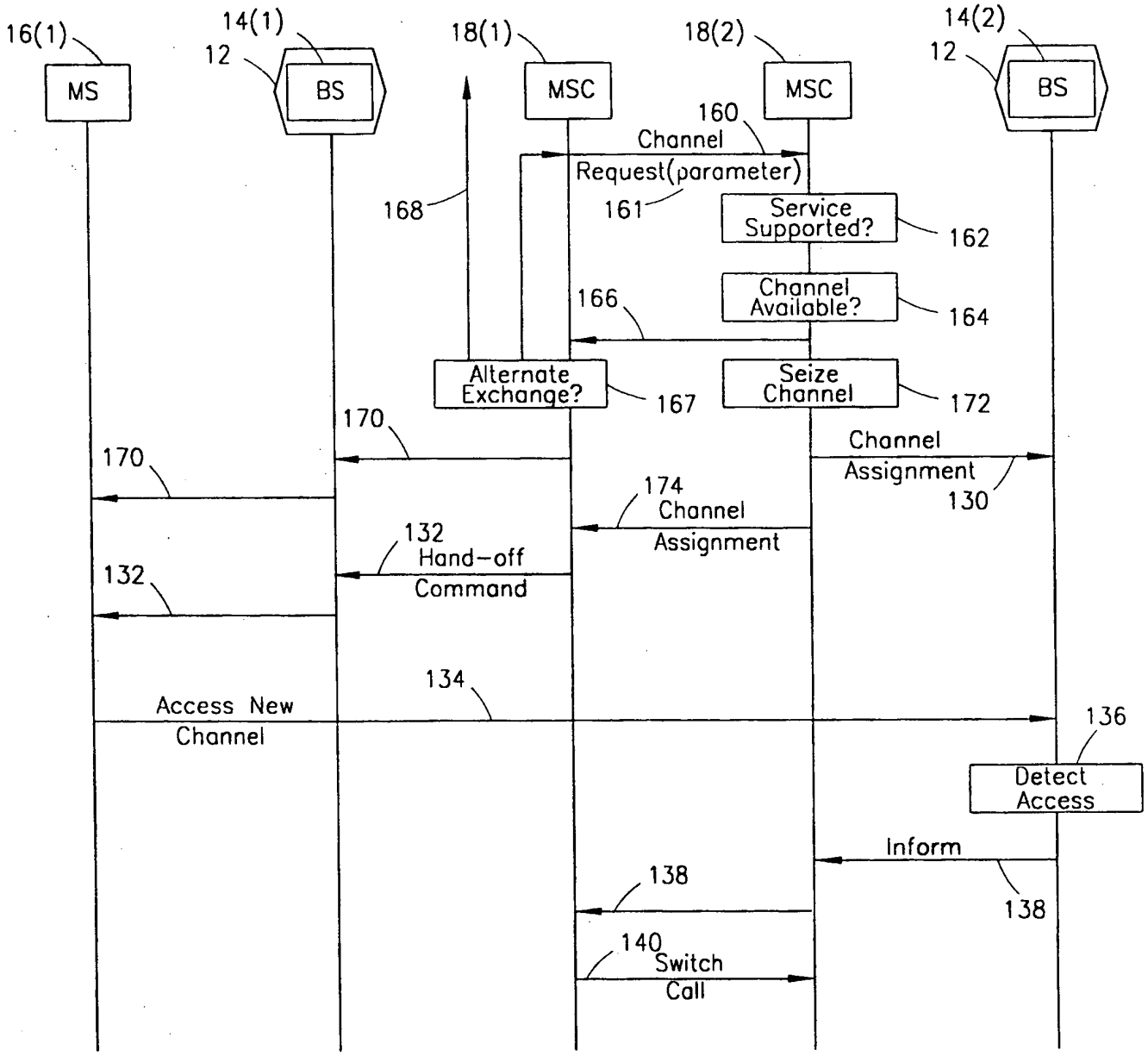

FIG. 4B